

# STATE OF DELAWARE BASELINE STATEWIDE VISUAL LITTER STUDY

**FINAL REPORT | JULY 2, 2018**

**PREPARED FOR:**

KEEP DELAWARE BEAUTIFUL  
DELAWARE SOLID WASTE AUTHORITY  
DELAWARE DEPT. OF TRANSPORTATION



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# Executive Summary

Concerns have been raised in Delaware that the amount of litter along State highways has increased significantly over the past several years. While this may be the case, there is no baseline litter study for Delaware against which to measure current levels of litter. For this reason, Keep Delaware Beautiful (KDB), in consultation with the Delaware Solid Waste Authority (DSWA) and the Delaware Department of Transportation (DelDOT), contracted with DSM Environmental Services, Inc. (DSM) and sub-contractor, MSW Consultants (together the Project Team) to conduct a statewide baseline visual litter survey.

The Project Team proposed, and KDB agreed, to use the same methodology as the *Keep America Beautiful National Visible Litter Survey* (2009 KAB National Study) conducted by MSW Consultants in 2008/9. Using the same methodology would allow Delaware to compare itself against the national survey (albeit nine years later) and would also provide a statistically valid baseline survey which could be duplicated in the future to measure trends in visible litter along Delaware highways.

## Methodology

The Project Team obtained centerline road miles for all Delaware State highways from the U.S. Census Bureau's Topologically Integrated Geographic Encoding and Referencing (TIGER) database. Sixty road segments were randomly selected for visual counting of litter along a 300 foot by 15-foot strip immediately adjacent to the edge of the road shoulder. Another twenty road segments were randomly selected for roads leading to the Delaware Solid Waste Authority (DSWA) Milford and Route 5 Transfer Stations because concerns have been raised that Delaware's Universal Recycling Law (requiring collection of single stream recycling) may be contributing to the litter problem. The goal was to compare average litter counts for these 20 road segments leading to the transfer stations against the 60 road segments randomly selected on all other US and State highways in Delaware.<sup>1</sup>

A data collection form was finalized based on a consolidated version of the 2009 KAB National Study and had seven major material categories and 27 subcategories for different litter items. Enumerators were trained in the methodology and material categories, which required litter be counted separately by piece for items greater than four inches and for items less than four inches.

Trained enumerators traveled to each pre-selected road segment and marked off the 300 by 15-foot segment prior to any data collection. The enumerator then counted all litter pieces greater than four inches within the 300 by 15-foot segment and counted all litter under four inches in a 15-foot square at the upper end of the 300-foot segment.<sup>2</sup>

Litter pieces for each surveyed road segment were then averaged for each litter category by road type (Interstate, US Routes, and State Routes) and normalized to derive an average number of litter pieces per centerline mile by road type.

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<sup>1</sup> A total of 80 road segments were part of the survey.

<sup>2</sup> This is the methodology followed in the National Litter Study.

## Results

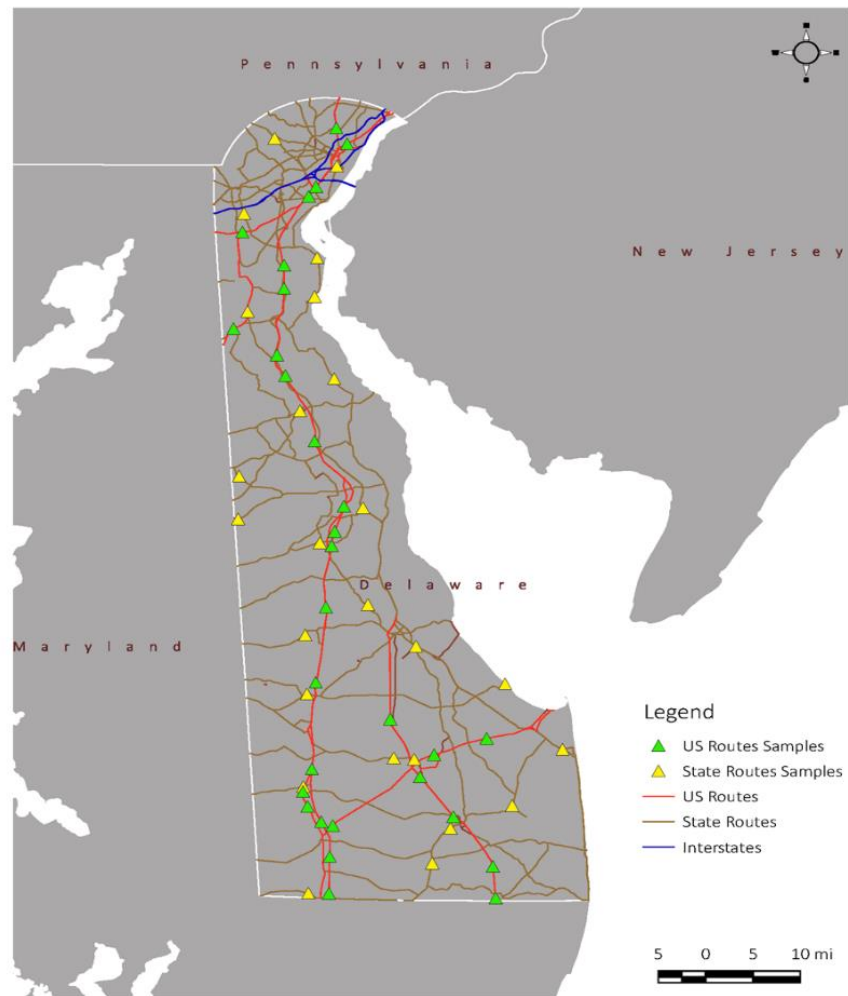
### Road Segments

The Project Team randomly selected 60 road segments (Figure E.1) allocated primarily among two Delaware road types based on the total mileage of each road type as shown in Table 1, with an additional ten road segments in a six-mile circumference of each of the two DSWA transfer stations accepting recyclables.<sup>3</sup>

**Table E-1. Delaware Centerline Road Miles by Road Type, And Number of Segments Surveyed**

Road Type	Calculated Miles	Pct	Surveys	Transfer Stations
Interstate	80.46	5%	2	0
US Routes	470.75	28%	28	9
State Routes	1122.05	67%	30	11
<b>TOTAL</b>	<b>1673.26</b>	<b>100%</b>	<b>60</b>	<b>20</b>

**Figure E-1.  
Visible Litter Survey  
Locations**



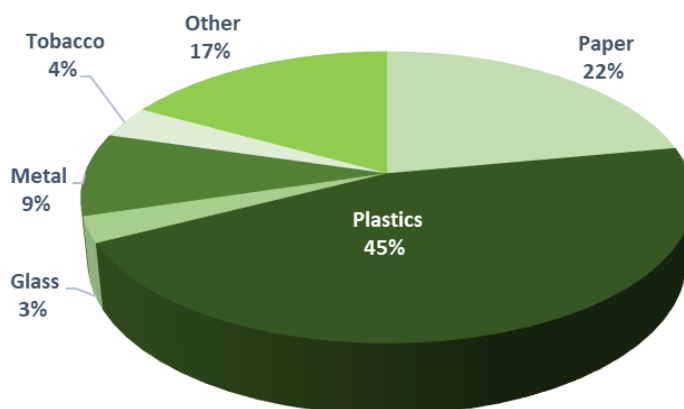
<sup>3</sup> Interstate roads were not a primary target for this study; however, two Interstate segments were randomly selected to compare/contrast against the US and State roads, which were the primary focal point.

### Litter Pieces Per Road Mile, Statewide Average

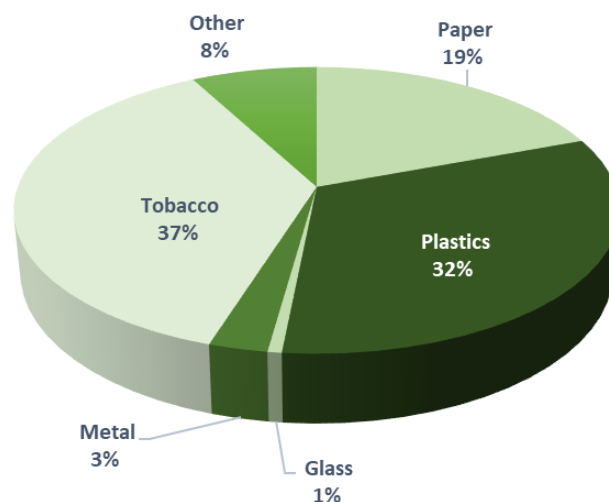
Because of the large impact of tobacco products (primarily cigarette butts) on litter pieces less than four inches, litter studies typically divide litter into larger and smaller pieces for reporting purposes.

On average, the Project Team estimates that there are 1,120 pieces of litter per centerline road mile greater than four inches in size, and 4,967 pieces of litter per mile less than four inches in size<sup>4</sup>. Figures E-2 and E-3 illustrate the percent of litter pieces by major material category.

**Figure E-2. Percent Composition of Litter by Material Type Four Inches or Greater in Size**



**Figure E-2. Composition of Litter by Material Type Less Than Four Inches in Size**



As illustrated by Figures E-2 and E-3, plastics are the predominant litter type for pieces four inches and greater, while tobacco products and plastics comprise just under 70 percent of all litter found under four inches in size.

<sup>4</sup> Pieces of litter per centerline road mile refer to one side of the road, which means that one would multiply the pieces per centerline by two to derive total litter along each mile of Delaware roads.

Table E-2 then compares statewide averages against county averages. Table E-2 presents pieces, weighted by total miles of each roadway type, both statewide and by county. As illustrated by Table E-2, New Castle County, with the highest population, has the highest amount of litter per road mile, while Kent County, with the lowest population has the lowest number of litter pieces per mile.<sup>5</sup> In general, there does not appear to be a statistically significant difference in litter by county.

**Table E-2. Comparison of Litter Pieces Per Mile by County**

MATERIAL	STATEWIDE		SUSSEX		KENT		NEW CASTLE	
	> 4	< 4	> 4	< 4	> 4	< 4	> 4	< 4
Paper	247	960	226	673	216	842	280	1,438
Rigid Plastics	263	291	317	246	198	226	248	355
Plastic Bags and Film	208	849	253	753	124	459	232	1,009
Expanded Polystyrene	37	461	58	225	25	154	32	817
Glass	32	32	44	45	11	-	29	-
Metal	103	135	160	167	48	174	93	70
Tobacco	40	1,850	43	1,489	37	1,816	40	2,601
Other	190	390	123	129	48	154	315	734
<b>Total</b>	<b>1,120</b>	<b>4,967</b>	<b>1,224</b>	<b>3,726</b>	<b>707</b>	<b>3,824</b>	<b>1,269</b>	<b>7,024</b>

### Contribution of Universal Recycling to Visible Litter

One goal of this study was to compare litter accumulation on roads leading to the two DSWA transfer stations that accept single stream recyclables collected by haulers against statewide visible litter totals, exclusive of the roads to the two transfer stations.

As illustrated by Table E-3, there does not appear to be a significant difference in total visible litter along roads leading to the DSWA transfer stations when compared to statewide litter pieces per mile, especially for pieces four inches and greater. There are increases in both rigid plastics and plastic film for pieces under four inches. However, given the variabilities of mowing which impact pieces under four inches and the relatively large confidence intervals calculated for lighter material such as plastics, it is most likely that the averages for transfer station roads fall within the confidence intervals for the statewide totals.

**Table E-3. Comparison of Litter Pieces Per Mile, Statewide Average and Leading to Transfer Stations**

MATERIAL	STATEWIDE		TRANSFER STATIONS	
	> 4	< 4	> 4	< 4
Paper	247	960	205	415
Rigid Plastics	263	291	246	453
Plastic Bags and Film	208	849	256	1,038
Expanded Polystyrene	37	461	47	217
Glass	32	32	39	141
Metal	103	135	78	166
Tobacco	40	1,850	26	1,061
Other	190	390	130	285
<b>Total</b>	<b>1,120</b>	<b>4,967</b>	<b>1,027</b>	<b>3,776</b>

<sup>5</sup> Because of the relatively small sample size (60) over 1,673 miles of roads, the confidence intervals for many materials sampled are quite high meaning that the variance among counties by material type falls within the confidence intervals of the statewide results.

## Comparison With 2009 National Data

The 2009 KAB National Study also reported the number of four- inch and greater and less than four-inch pieces per mile.<sup>6</sup> Table E-4 compares the pieces per mile from the 2009 National Study to the observed littering rate in Delaware. This table suggests that Delaware litter differs from the national average, with a higher incidence of large litter items found in Delaware compared to the National Study and significantly fewer small items.

**Table E-4. Comparison of 2018 Delaware Visible Litter to 2009 KAB National Study**

Litter Size	Delaware 2018	KAB National	
		2009	Difference
Large (4"+)	1,120	608	512
Small (4"-)	4,967	6,729	-1,762
<b>Total Litter</b>	<b>6,087</b>	<b>7,337</b>	<b>-1,250</b>

The difference in large litter items may be significant, but it is the Project Team's professional opinion that because the National Study was completed nine years ago accounts for much of the difference in large litter pieces. Plastic generation, and plastic as a percent of litter, continues to grow when compared to other material types. This is illustrated by the fact that plastic, as percent of total litter, is roughly 10 percentage points higher in Delaware (2018) than was reported in the National Study (2009).

It is the Project Team's understanding that Keep America Beautiful is currently conducting a new national study (2018) which would mean that the results should be available sometime in early 2019. An addendum to this report will be prepared at that time comparing the new national study against this Delaware specific study.

Interestingly, almost all the difference in small litter is attributable to significantly fewer tobacco-related litter items, predominantly cigarette butts, in Delaware compared to the National Study. It was beyond the scope of this study to investigate the reasons for this difference; however, the U.S. Federal Trade Commission reports that cigarette sales have decreased from 290.6 billion individual cigarettes in 2009 to 240.5 billion in 2016, the latest year for which data are reported.<sup>7</sup> This represents a 17 percent decrease in the number of cigarette butts and related packaging available to be littered.

<sup>6</sup> The National Study included both mowed and un-mowed segments just as Delaware's does.

<sup>7</sup> Federal Trade Commission Cigarette Report for 2016, issued 2018.

# FULL REPORT | Delaware Baseline Statewide Visual Litter Survey

## Background

Concerns have been raised in Delaware that the amount of litter along State highways has increased significantly over the past several years. While this may be the case, there is no baseline litter data for Delaware against which to measure current levels of litter.<sup>8</sup> For this reason, Keep Delaware Beautiful (KDB) in consultation with the Delaware Solid Waste Authority (DSWA) and the Delaware Department of Transportation (DelDOT) contracted with DSM Environmental Services, Inc. (DSM) and sub-contractor, MSW Consultants (together the Project Team) to conduct a statewide baseline visual litter survey.

The Project Team proposed, and KDB agreed, to use substantially the same methodology as the Keep America Beautiful, National Visible Litter Survey (2009 KAB National Study) that was conducted by MSW Consultants in 2008/9. Using the same methodology would allow Delaware to compare itself against the national survey (albeit nine years later) and would also provide a statistically valid baseline survey which could be duplicated in the future to measure trends in visible litter along Delaware highways.

DSWA is involved in this survey because there has been some conjecture that one of the impacts of the Universal Recycling Law is increased litter coming from recycling trucks who collect loose recyclables from carts and deliver recyclables to the two DSWA transfer stations (Route 5 and Milford). Therefore, DSWA agreed to contribute additional funds to allow for 10 additional litter surveys in a six-mile radius around each of the two recycling transfer stations. These additional 20 surveys could then be compared against the statewide average of litter per road mile to determine if there was any statistical difference in the amount of litter between roads leading to the two transfer stations, and the rest of the roads in Delaware surveyed.



**LITTER PIECE COUNTING: LARGE (> 4") PIECES (ABOVE)  
AND SMALL PIECES (<4"), AT RIGHT**

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<sup>8</sup> In fact, Delaware was one of only five states that were not surveyed in the 2009 National Litter Study, although the national data were not statistically relevant at the state level in any case.



# Methodology

## Materials Accounted For

The Project Team originally proposed that the survey count and allocate litter into twenty material categories, which is a reduced list compared to the 2009 KAB National Study but which retains critical distinctions for litter types. Ultimately, after discussions with the Project Sponsors, the number of categories was increased to 27 material types divided into seven major material categories, as illustrated in Table 1, below.

Note that plastics have been divided into two categories – Rigid and Non-Rigid. Rigid plastics consist of plastic containers typically used for food and beverages, as well as toys and five-gallon pails. Non-rigid plastics include plastic bags, of which retail bags are only one portion, as well as all other plastic film, including tarps, pallet wrap and shrink wrap films. Expanded Polystyrene, typically called by the brand name “Styrofoam,” has also been included in non-rigid plastic because it is very lightweight and typically behaves like film when littered.

**Table 1.**  
**Material Categories Quantified During the Litter Survey**

Material Group	No.	Material Type	Material Description
Paper	1	OCC	Corrugated Cardboard usually has three layers. The center wavy layer is sandwiched between the two outer layers. It may have a wax coating on the inside or outside. Examples include entire cardboard containers, such as shipping and moving boxes, computer packaging cartons, and sheets and pieces of boxes and cartons. This type does not include chipboard
	2	Recyclable Paper	Includes printed paper, such as paper back books, newspapers, boxboard (chipboard), office paper, folders, envelopes, notebook paper, mail, advertisements, signs, cards, glossy inserts, receipts, etc.
	3	Single-Use Food Service	Paper items used to serve one-time or fast-food service items originating from restaurants, taverns, drive-ins, concessions, the fast-food section of a grocery store, and other such establishments. Examples include paper cups, plates, bowls, wrappings, individual serving condiment packages, cups and beverage holders, napkins or towels, pizza boxes, and paper/kraft bags known to be from such establishments and grocery stores.
	4	Other Paper	Includes any other paper product not mentioned above including tissue paper and paper towels.
Rigid Plastic	5	Beverage Bottles	Carbonated and non-carbonated beverage bottles, excluding dairy
	6	Alcohol Bottles	Bottles packaging beer, wine or alcohol
	7	Bottles	Plastic bottles of any size and any resin not used for beverages, but including dairy.
	8	Single-Use Food Service	Plastic items (excluding styrofoam) used to serve one-time or fast-food service items originating from restaurants, taverns, drive-ins, concessions, the fast-food section of a grocery store, and other such establishments. Examples include plastic cups, lids, straws, utensils, plates, bowls, wrappings, individual serving condiment packages, cup and beverage holders. Includes items still containing food.
	9	Other Plastic Packaging	All other non-film packaging that does not fit into the above categories
	10	Other/Non-Packaging Plastics	Plastic items not intended for packaging or that do not fit into the above categories. Includes durable plastic products and pails
Non-Rigid Plastic	11	Plastic Bags	Plastic trash bags, and plastic grocery, and other merchandise shopping bags used to contain merchandise to transport from the place of purchase, given out by the store with the purchase (including dry cleaning bags).
	12	Other Film	Flexible and multi-layer film bags and packaging such as used to package candy, gum, chips, other food items, as well as all other non-bag plastic film.
	13	Expanded Polystyrene	Expanded polystyrene (EPS) packaging of all types including food service, single use (plates, cups), "peanuts" and other formed EPS.
Glass	14	Alcohol Bottles	Bottles or pieces that were used to package beer, wine or liquor
	15	Beverage Container	Glass bottles or containers of any size designed to contain a beverage other than alcohol
	16	Other Ceramic or Glass	Food bottles, and non-bottle glass, broken glass, if not easily identifiable as beverage glass, and ceramics.
Metal	17	Aluminum Alcohol Cans	All aluminum cans used to package beer or other alcoholic beverages
	18	Aluminum Cans	Aluminum cans of any size, usually containing a non-alcoholic beverage.
	19	Other Metal	Products made entirely from metal or predominantly metal products. Includes ferrous and non-ferrous metal, such as clothes hangers, aluminum foil, copper, zinc, and brass.
Human Waste	20	Human Wastes	Examples include disposable baby diapers, feminine products, protective undergarments for adults. Also includes needles, syringes, I.V. tubing, medications, ointments, creams, etc. used to heal persons or animals. Containers of any size or shape that contain human feces or urine.
Organic	21	Food	Any item of food, excluding packaging. This includes loose food items like banana peels, apple cores and chewing gum.
Tobacco	22	Cigarette Butts, Cigar Tips and All Other Tobacco-Related Products and Packaging	The discarded ends, pieces or filters of fully or partially smoked cigarettes or cigars. Unsmoked cigarettes, cigars, chewing tobacco, pipe tobacco, matches, matchbooks and packaging for tobacco products such as paper boxes, plastic or foil wrappings, or other materials used to package cigarettes, cigars, chewing or pipe tobacco, including individual cigarette packages and unused cigarette papers.
	23	Vehicle Debris	Vehicle hubcaps, tailpipes, tires of all types (including bicycle tires), and tire rims if attached. Molding, tire retread, exterior light covers, rearview mirrors, lights, or window glass known to be from an automobile or other motorized vehicle. Auto body parts from accidents.
Other	24	Other Items	Any other material not otherwise described.
	25	Full Trash Bags	Garbage bags with material in them

## Roadway Site Sampling Plan

Consistent with the 2009 KAB National Study, roadways were defined according to the U.S. Census Bureau's Topologically Integrated Geographic Encoding and Referencing (TIGER) map database, which defines the following roadway classes which were ultimately included in the study<sup>9</sup>:

- **Interstates:** These are high speed limited access federal roadways. In Delaware this includes I-95, I-295 and I-495.
- **US Routes:** Sometimes called federal highways, US Routes are high speed numbered routes within a nationwide grid (i.e., they usually span more than one state). Despite the nomenclature, US Routes are maintained by the state, and examples in Delaware include Highway 13 and Highway 301.
- **State Routes:** State routes are higher speed primary and arterial roads that fall entirely within a state and are numbered (and maintained) by the state. Examples in Delaware include State Highways 1 and 9.

This database provides the centerline mileage for each of the targeted roadway types. Table 2 shows the total centerline miles for each roadway type, along with the corresponding percentage of the total centerline mileage for all targeted roadway types.

**Table 2. Centerline Miles by Road Type**

Road Type	Calculated Miles	Pct
Interstate	80.5	5%
US Routes	470.8	28%
State Routes	1122.0	67%
<b>TOTAL</b>	<b>1673.3</b>	<b>100%</b>

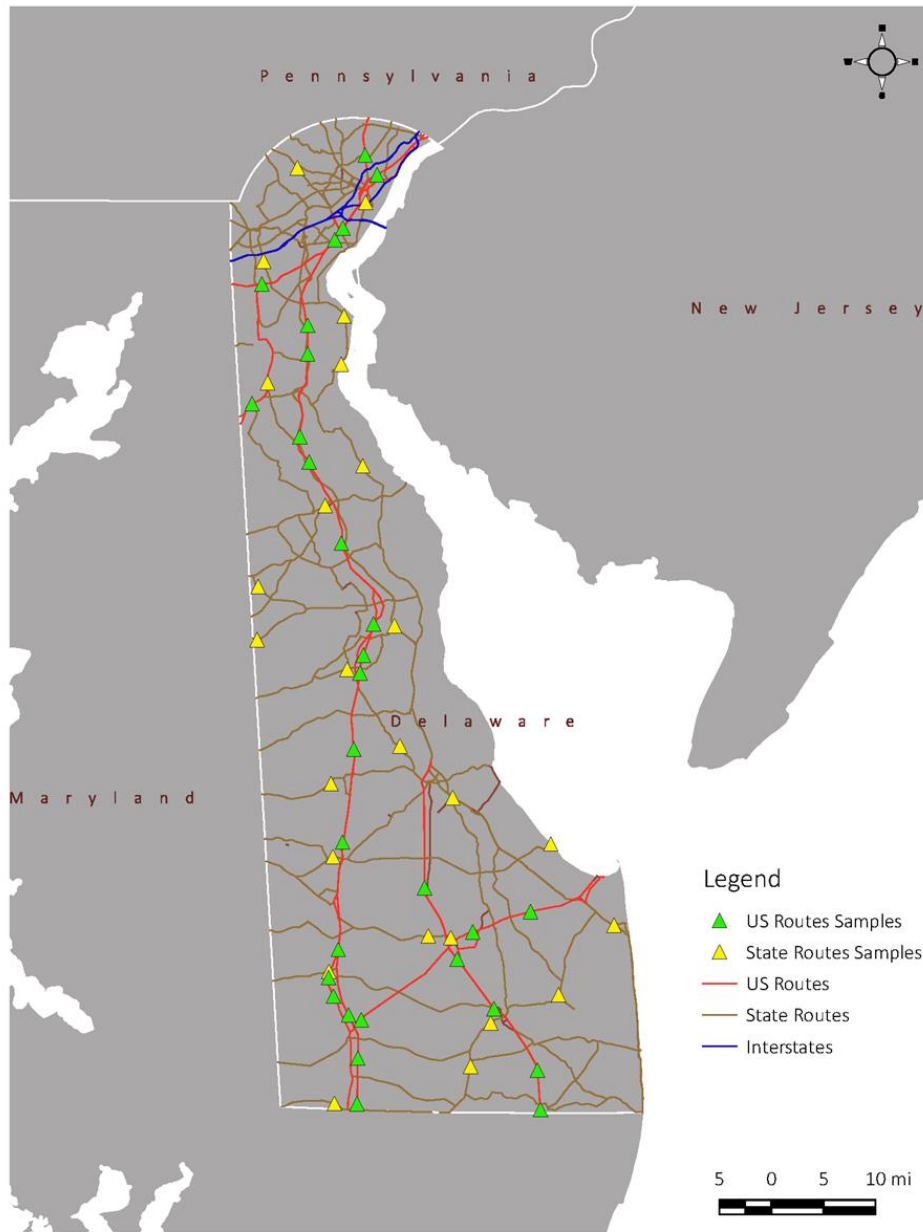
It was agreed as part of the study design that the majority of sampling should target the US Routes and State Routes. Accordingly, the study randomly selected 30 roadway segments from each roadway type. The selection process essentially entailed stringing together every centerline mile of each roadway class, dividing the total mileage by the number of samples to create a sampling interval, and then selecting the roadway segment that was found to fall on each sampling interval.

It was further determined during the study design process that only limited sampling should be performed on Interstates. This decision was based on a combination of safety concerns and also the recognition that DelDOT does not perform litter remediation on most of the Interstate system. However, it was determined that two samples should be obtained from I-495. The segments were selected in the same manner as the US and State Routes segments, and two US segments were randomly discarded to leave the sampling target at 60 samples. Figure 1 illustrates the survey locations by roadway type.

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<sup>9</sup> The TIGER database also includes municipal roads, which are local roads within incorporated cities and towns; however, municipal roads were not included in this study.

**Figure 1. Survey Locations**



### Impact of Seasons and Mowing

Mowing has a significant impact on litter surveys because the survey counts pieces, which are significantly increased after roadside mowing. Mowing is common along highways across the country, and it is difficult to design a survey that excludes highways that are not mowed. As such, the survey includes both mowed and un-mowed sections, indicative of normal summer conditions.

## *Visible Litter Survey Methodology*

The enumerator was provided with a GPS coordinate for each survey site. Upon arrival the enumerator measured a 300-foot rectangle, 15 feet wide, flagging the four corners. In addition, the enumerator flagged a 15-foot square at the top of the rectangle. The enumerator then proceeded to count and record each piece of litter by material subcategory under 4 inches in the 15-foot square. Once that was completed, the enumerator walked the 300 foot by 15-foot rectangle and counted and recorded all pieces greater than 4 inches by material category.

In the event where the enumerator encountered an obstacle preventing the survey (e.g., road intersection, dangerous location), the enumerator continued past the designated site to the first available 300-foot section that could be surveyed.

The enumerator also took pictures of the site and noted any pertinent information concerning the site (e.g., next to a fast food restaurant, mowed or un-mowed, evidence that clean-up had occurred recently, type of highway and setting).

### *Litter Particle Size*

Consistent with the 2009 KAB National Study methodology, the data are reported separately for pieces four inches and greater and those under four inches because of the impact that tobacco products - primarily cigarette butts - have on the totals. Because the data are measured and reported in pieces, not by weight, tobacco item piece counts tend to overwhelm other visible litter piece counts when reported combined with all other results, even though they are often not very visible along the road itself.

## *Roadway Surveying Procedure*

The following steps summarize the salient considerations for surveying the randomly selected roadway segments:

- **Segment length:** 300 feet
- **Depth from shoulder edge:** 15 feet
- **Large piece count:** performed over the entire 4,500 square foot rectangle (300'x15')
- **Small piece count:** performed over the first 15'x15' end of the selected roadway segment

Both large and small piece counts were performed via manual observation meandering from roadside to 15' depth for the segment. Enumerators carried a measuring tool to uncover litter and also to confirm the dimensions of litter pieces. Each roadway segment was photographed and relevant data concerning the roadway segment recorded (e.g., mowed or un-mowed, appeared to be recently cleaned, near a fast food or convenience store).



### Drone Videography vs Manual Enumeration

At the outset of the project, the Project Team opted to test the use of a piloted drone to video the roadway segments and potentially to record and compile litter piece counts from the high-resolution video. Video capture was performed by a certified drone pilot using a DJI Phantom 4 Pro with a 4k resolution camera. The outset of the project was therefore devoted to comparing the resolution and accuracy of the drone video with a manual count.

The drone provided incredibly robust imagery of the location and surrounding areas for each roadway segment. Recording the roadway segment view at an altitude of 30 to 50 feet identified intersections, stores, vegetation, and other features that may impact litter generation and accumulation. Further, the drone was able to resolve a great deal of the litter when the video was reviewed afterwards.

However, the drone could not resolve litter to the degree possible by the enumerator. Despite the high-resolution video, it would have been necessary to dramatically reduce the altitude and slow the speed of drone video recording to achieve resolution comparable with manual meander counts. Such a process was found to have a material impact on data collection productivity, and also taxed the battery life of the drone over long days of data collection.

Because the project schedule and budget required two enumerators working simultaneously, and because drone data collection could not equate to manual data collection, the decision was made to perform manual meander counts for this study.



## Applying the Survey Results to Road Miles

The individual survey results were then aggregated by road type (Interstate, US Routes and State Routes) based on the number of center line miles by each road type, as presented in Table 3, below.

**Table 3. Centerline Miles and Number of Surveys by Road Type, State of Delaware**

Road Type	Calculated Miles	Pct	Surveys	Transfer Stations
Interstate	80.46	5%	2	0
US Routes	470.75	28%	28	9
State Routes	1122.05	67%	30	11
<b>TOTAL</b>	<b>1673.26</b>	<b>100%</b>	<b>60</b>	<b>20</b>

It should be noted that the two interstate roadway segments do not constitute a statistically robust sample population. However, the results of these two segments were consistent with other studies on interstate roads in highlighting the much higher incidence of litter on these roads, due to higher vehicle miles traveled. Further, at only five percent of the state's centerline miles, the impact of the interstate roadway segments is significantly reduced, and they are consequently left in the statewide weighted average.

An average litter count for the samples collected on each roadway type was then calculated and those averages multiplied by the number of road miles of that type to create a weighted average litter count for the statewide results. For example, 28 surveys were taken along the 470.75 US Route miles. Each survey was for a 300-foot strip. The survey results were assumed to be representative of the entire 470.75 miles so the average of the 28 samples were multiplied by 17.6 (5,280/300) to create an average number of large pieces per centerline mile on US Routes.

The surveys specific to the transfer stations were not included in the weighted average statewide litter counts so that a true comparison between the road segments surveyed around the transfer stations could be compared against the statewide average.

### Differences with the National Study Methodology

The 2009 KAB National Study undertook a more ambitious, and more qualitative, approach to quantifying litter. It has already been mentioned that the Delaware study reduced the number of material categories compared to the National Study. However, the Delaware material categories maintain sufficient differentiation to explain the cause and distribution of litter through the environment.

Additionally, the Delaware study did not attempt to estimate the source of litter as was done in the national study. This exercise was found to be difficult for the 2009 KAB National Study for many littered items and it is unlikely that the sources of litter in Delaware are significantly different from the sources of litter in the National Study (i.e., the distribution is likely to be comparable). However, of greater interest at this time, the Delaware study did separately analyze litter incidence on the roadways leading to DSWA's two transfer stations accepting single stream recyclables to test the hypothesis that windblown items from waste and recycling collection trucks disproportionately litter these roads.

# Results

## Statewide Results

Tables 4 and 5 present the Statewide results for visible litter four inches and greater and under four inches, respectively.

**Table 4. Weighted Average Statewide Visible Litter, Pieces Per Mile, Four Inches and Greater**

Material	Pieces per Mile			Group	Pieces per Mile		
	Average	Conf. Int. (90%)	Composition		Average	Conf. Int. (90%)	Composition
<b>Rigid Plastic</b>	<b>262.9</b>	<b>49.1</b>	<b>23.5%</b>	<b>Paper</b>	<b>247.2</b>	<b>62.6</b>	<b>22.1%</b>
Beverage Bottles	100.2	25.4	8.9%	OCC	37.3	17.8	3.3%
Alcohol Bottles	38.6	10.6	3.4%	Recyclable Paper	77.1	37.2	6.9%
Bottles	14.5	7.9	1.3%	Single-Use Food Service	62.8	14.1	5.6%
Single-Use Food Service	78.9	17.8	7.0%	Other Paper	70.0	19.2	6.2%
Other Plastic Packaging	8.6	3.1	0.8%				
Other/Non-Packaging Plastics	22.1	8.3	2.0%	<b>Metal</b>	<b>102.6</b>	<b>25.0</b>	<b>9.2%</b>
				Aluminum Alcohol Cans	48.8	15.0	4.4%
<b>Non-Rigid Plastics</b>	<b>245.9</b>	<b>59.9</b>	<b>22.0%</b>	Aluminum Cans	42.4	10.3	3.8%
Plastic Bags	47.6	16.3	4.2%	Other Metal	11.3	5.0	1.0%
Other Film	160.9	38.6	14.4%				
Expanded Polystyrene	37.5	14.7	3.3%	<b>Other</b>	<b>190.0</b>	<b>81.1</b>	<b>17.0%</b>
				Human Wastes	0.4	0.5	0.0%
<b>Glass</b>	<b>32.2</b>	<b>9.2</b>	<b>2.9%</b>	Food	2.0	1.4	0.2%
Alcohol Bottles	21.5	6.8	1.9%	Construction Materials	89.2	63.6	8.0%
Beverage Containers	5.7	2.2	0.5%	Textiles/Shoes	20.0	6.6	1.8%
Other Ceramic or Glass	5.0	2.2	0.4%	Bulky Items	-	Not found	0.0%
				Vehicle Debris	65.2	22.2	5.8%
<b>Tobacco</b>	<b>39.6</b>	<b>9.3</b>	<b>3.5%</b>	Other Items	13.3	4.8	1.2%
Cigarette Butts, Cigar Tips, et	39.6	9.3	3.5%				
<b>Total</b>					<b>1,120.4</b>		<b>100.0%</b>
<b>No. of Samples</b>					<b>60.0</b>		

**Table 5. Weighted Average Statewide Visible Litter, Pieces Per Mile Less Than Four Inches**

Material	Pieces per Mile			Group	Pieces per Mile		
	Average	Conf. Int. (90%)	Composition		Average	Conf. Int. (90%)	Composition
<b>Rigid Plastic</b>	<b>291.2</b>	<b>95.8</b>	<b>5.9%</b>	<b>Paper</b>	<b>959.9</b>	<b>476.0</b>	<b>19.3%</b>
Beverage Bottles	24.8	43.7	0.5%	OCC	24.8	58.5	0.5%
Alcohol Bottles	-	Not found	0.0%	Recyclable Paper	558.2	441.3	11.2%
Bottles	-	Not found	0.0%	Single-Use Food Service	118.9	61.5	2.4%
Single-Use Food Service	83.0	58.9	1.7%	Other Paper	258.0	87.4	5.2%
Other Plastic Packaging	47.4	40.1	1.0%				
Other/Non-Packaging Plastics	136.0	47.3	2.7%	<b>Metal</b>	<b>134.6</b>	<b>81.8</b>	<b>2.7%</b>
				Aluminum Alcohol Cans	10.6	28.9	0.2%
<b>Non-Rigid Plastics</b>	<b>1,309.8</b>	<b>439.7</b>	<b>26.4%</b>	Aluminum Cans	21.3	39.6	0.4%
Plastic Bags	31.9	49.8	0.6%	Other Metal	102.7	70.7	2.1%
Other Film	816.8	244.5	16.4%				
Expanded Polystyrene	461.1	237.7	9.3%	<b>Other</b>	<b>389.8</b>	<b>197.0</b>	<b>7.8%</b>
				Human Wastes	-	Not found	0.0%
<b>Glass</b>	<b>32.1</b>	<b>30.4</b>	<b>0.6%</b>	Food	7.2	9.6	0.1%
Alcohol Bottles	24.9	28.9	0.5%	Construction Materials	117.2	106.6	2.4%
Beverage Containers	-	Not found	0.0%	Textiles/Shoes	25.0	18.8	0.5%
Other Ceramic or Glass	7.2	9.6	0.1%	Bulky Items	-	Not found	0.0%
				Vehicle Debris	215.4	153.8	4.3%
<b>Tobacco</b>	<b>1,849.5</b>	<b>479.5</b>	<b>37.2%</b>	Other Items	25.0	16.4	0.5%
Cigarette Butts, Cigar Tips	1,849.5	479.5	37.2%				
<b>Total</b>					<b>4,966.9</b>		<b>100.0%</b>
<b>No. of Samples</b>					<b>60.0</b>		

The 2009 KAB National Study also reported the number of litter pieces per mile. Table 6 compares pieces per mile from the National Study to the observed littering rate in Delaware. This table suggests that Delaware litter differs from the national average observed in 2009. A higher incidence of large litter items was found in Delaware compared to the National Study, while the number of small items was significantly lower.

**Table 6. Comparison of 2018 Delaware Visible Litter Survey Results to 2009 KAB National Study**

Litter Size	Delaware 2018	KAB National	
		2009	Difference
Large (4"+)	1,120	608	512
Small (4"-)	4,967	6,729	-1,762
<b>Total Litter</b>	<b>6,087</b>	<b>7,337</b>	<b>-1,250</b>

While it is speculative, it is likely that the difference in large litter pieces observed in Delaware is the result of the continuing increase in plastic use in the United States subsequent to 2009. For example, large plastic litter represented 35 percent of total pieces in the 2009 KAB National Study and represent 45 percent of the total for Delaware. This is consistent with the reported 165 percent increase in plastic litter pieces reported in the 2009 National Study when compared to the 1969 National Study. As such, the Project Team recommends that Delaware wait until the results of the 2018 National Study are published by Keep America Beautiful before drawing any conclusions comparing Delaware litter to national litter rates.

Interestingly, almost all of the difference in small litter is attributable to significantly fewer tobacco-related litter items, predominantly cigarette butts, in Delaware compared to the National Study. It was beyond the scope of this study to investigate the reasons for this difference; however, the U.S. Federal Trade Commission reports that cigarette sales have decreased from 290.6 billion individual cigarettes in 2009 to 240.5 billion in 2016, the latest year for which data are reported.<sup>10</sup> This represents a 17 percent decrease in the number of cigarette butts and related packaging available to be littered.

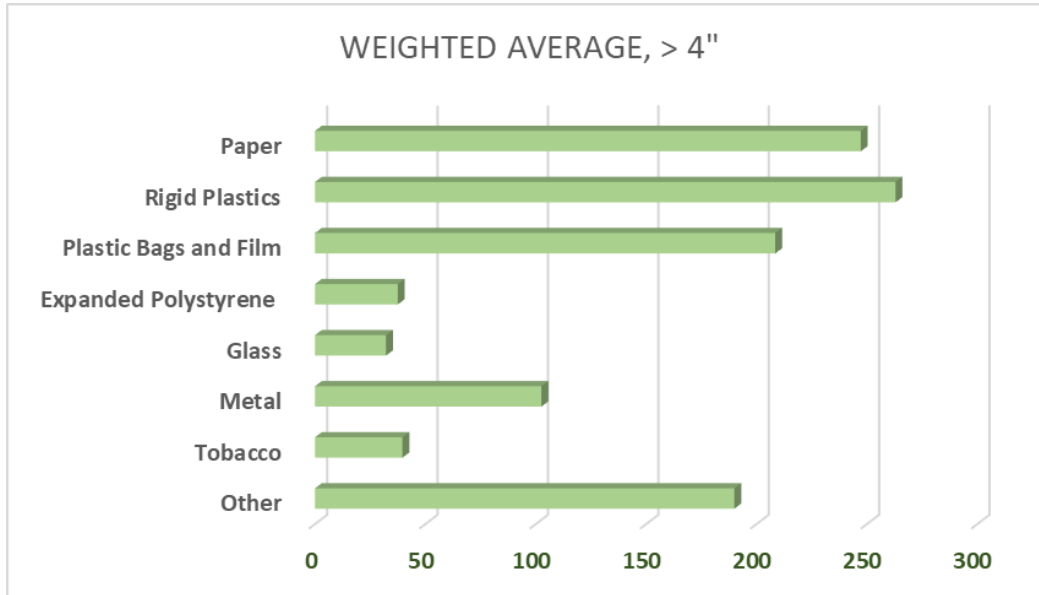
### Composition of Litter

Efforts to address litter are better informed by the types of litter. Figures 2 and 3 present bar charts illustrating pieces of litter by type based on the statewide weighted average pieces per mile. As illustrated by Figure 2, especially, which excludes most cigarette related litter, plastics dominate the composition of visible litter observed along Delaware roadways.

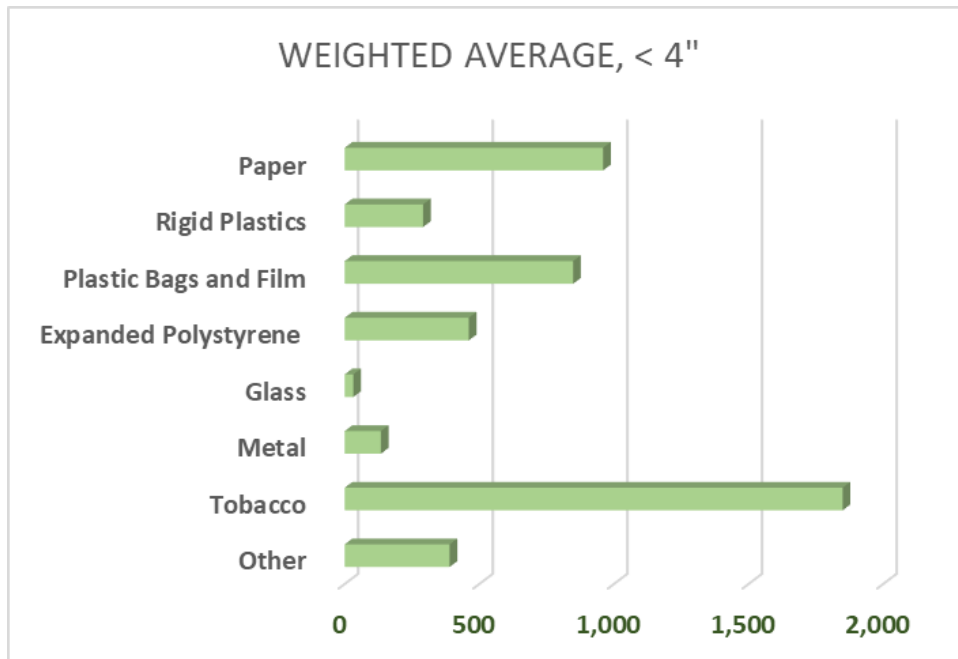
<sup>10</sup> Federal Trade Commission Cigarette Report for 2016, issued 2018.



**Figure 2. Composition of Litter > 4" by Material Category, Statewide Weighted Average (Pieces Per Road Mile)**



**Figure 3. Composition of Litter < 4" by Material Category, Statewide Weighted Average (Pieces Per Road Mile)**



## Results by County

Table 7 compares the survey results by county for the major material categories. Tables 8 through 13 then present detailed data by material type for each county.

**Table 7. Comparison of County Data, Litter Pieces Per Mile**

MATERIAL	SUSSEX		KENT		NEW CASTLE	
	> 4	< 4	> 4	< 4	> 4	< 4
Paper	226	673	216	842	280	1,438
Rigid Plastics	317	246	198	226	248	355
Plastic Bags and Film	253	753	124	459	232	1,009
Expanded Polystyrene	58	225	25	154	32	817
Glass	44	45	11	-	29	-
Metal	160	167	48	174	93	70
Tobacco	43	1,489	37	1,816	40	2,601
Other	123	129	48	154	315	734
<b>Total</b>	<b>1,224</b>	<b>3,726</b>	<b>707</b>	<b>3,824</b>	<b>1,269</b>	<b>7,024</b>

## New Castle County

**Table 8. Visible Litter Four Inches and Greater, New Castle County**

Material	Pieces per Mile			Group	Pieces per Mile		
	Average	Conf. Int. (90%)	Composition		Average	Conf. Int. (90%)	Composition
<b>Rigid Plastic</b>	<b>248.1</b>	<b>83.3</b>	<b>19.6%</b>	<b>Paper</b>	<b>279.7</b>	<b>143.3</b>	<b>22.0%</b>
Beverage Bottles	88.2	38.8	7.0%	OCC	48.6	39.8	3.8%
Alcohol Bottles	40.8	22.7	3.2%	Recyclable Paper	126.2	94.1	9.9%
Bottles	9.9	5.1	0.8%	Single-Use Food Service	52.2	16.6	4.1%
Single-Use Food Service	77.6	30.8	6.1%	Other Paper	52.7	23.1	4.2%
Other Plastic Packaging	13.3	7.2	1.0%				
Other/Non-Packaging Plastics	18.4	9.4	1.4%	<b>Metal</b>	<b>93.3</b>	<b>38.0</b>	<b>7.4%</b>
				Aluminum Alcohol Cans	44.1	24.7	3.5%
				Aluminum Cans	32.5	13.1	2.6%
<b>Non-Rigid Plastics</b>	<b>263.8</b>	<b>104.3</b>	<b>20.8%</b>	Other Metal	16.7	10.7	1.3%
Plastic Bags	56.2	21.6	4.4%				
Other Film	176.0	77.7	13.9%	<b>Other</b>	<b>315.4</b>	<b>217.4</b>	<b>24.9%</b>
Expanded Polystyrene	31.5	16.9	2.5%	Human Wastes	1.1	1.4	0.1%
				Food	2.7	3.0	0.2%
<b>Glass</b>	<b>28.6</b>	<b>18.6</b>	<b>2.3%</b>	Construction Materials	170.3	178.1	13.4%
Alcohol Bottles	19.1	11.8	1.5%	Textiles/Shoes	29.8	12.0	2.3%
Beverage Containers	3.9	3.2	0.3%	Bulky Items	-	Not found	0.0%
Other Ceramic or Glass	5.7	5.6	0.4%	Vehicle Debris	96.5	50.4	7.6%
				Other Items	15.0	8.9	1.2%
<b>Tobacco</b>	<b>40.0</b>	<b>15.9</b>	<b>3.2%</b>				
Cigarette Butts, Cigar Tips, et	40.0	15.9	3.2%				
				<b>Total</b>	<b>1,268.9</b>		<b>100%</b>
				<b>No. of Samples</b>	<b>21.0</b>		

**Table 9. Visible Litter Less Than Four Inches, New Castle County**

Material	Pieces per Mile			Group	Pieces per Mile		
	Average	Conf. Int. (90%)	Composition		Average	Conf. Int. (90%)	Composition
<b>Rigid Plastic</b>	<b>355.0</b>	<b>213.7</b>	<b>5.1%</b>	<b>Paper</b>	<b>1,438.0</b>	<b>1,174.7</b>	<b>20.5%</b>
Beverage Bottles	37.9	110.3	0.5%	OCC	9.5	27.6	0.1%
Alcohol Bottles	-	Not found	0.0%	Recyclable Paper	1,046.3	1,163.1	14.9%
Bottles	-	Not found	0.0%	Single-Use Food Service	184.5	117.3	2.6%
Single-Use Food Service	137.3	152.5	2.0%	Other Paper	197.7	85.9	2.8%
Other Plastic Packaging	19.9	27.6	0.3%				
Other/Non-Packaging Plastics	159.9	84.5	2.3%	<b>Metal</b>	<b>70.0</b>	<b>90.6</b>	<b>1.0%</b>
				Aluminum Alcohol Cans	0	Not found	0.0%
<b>Non-Rigid Plastics</b>	<b>1,826.4</b>	<b>1,150.1</b>	<b>26.0%</b>	Aluminum Cans	0	Not found	0.0%
Plastic Bags	9.5	27.6	0.1%	Other Metal	70.0	90.6	1.0%
Other Film	999.8	574.7	14.2%				
Expanded Polystyrene	817.2	640.7	11.6%	<b>Other</b>	<b>733.8</b>	<b>513.4</b>	<b>10.4%</b>
				Human Wastes	-	Not found	0.0%
<b>Glass</b>	<b>-</b>	<b>Not found</b>	<b>0.0%</b>	Food	-	Not found	0.0%
Alcohol Bottles	-	Not found	0.0%	Construction Materials	253.8	291.7	3.6%
Beverage Containers	-	Not found	0.0%	Textiles/Shoes	22.7	27.6	0.3%
Other Ceramic or Glass	-	Not found	0.0%	Bulky Items	-	Not found	0.0%
				Vehicle Debris	434.6	408.1	6.2%
<b>Tobacco</b>	<b>2,600.5</b>	<b>841.1</b>	<b>37.0%</b>	Other Items	22.7	27.6	0.3%
Cigarette Butts, Cigar Tips	2,600.5	841.1	37.0%				
				<b>Total</b>	<b>7,023.7</b>		<b>100%</b>
				<b>No. of Samples</b>	<b>21.0</b>		

## Kent County

**Table 10. Visible Litter Greater Than Four Inches, Kent County**

Material	Pieces per Mile			Group	Pieces per Mile		
	Average	Conf. Int. (90%)	Composition		Average	Conf. Int. (90%)	Composition
<b>Rigid Plastic</b>	<b>197.9</b>	<b>86.0</b>	<b>28.0%</b>	<b>Paper</b>	<b>215.5</b>	<b>127.1</b>	<b>30.5%</b>
Beverage Bottles	53.6	33.4	7.6%	OCC	26.4	24.7	3.7%
Alcohol Bottles	35.6	20.7	5.0%	Recyclable Paper	36.7	45.0	5.2%
Bottles	21.1	31.2	3.0%	Single-Use Food Service	63.5	28.1	9.0%
Single-Use Food Service	78.5	38.1	11.1%	Other Paper	88.9	70.2	12.6%
Other Plastic Packaging	3.6	4.8	0.5%				
Other/Non-Packaging Plastics	5.5	3.9	0.8%	<b>Metal</b>	<b>47.6</b>	<b>25.2</b>	<b>6.7%</b>
				Aluminum Alcohol Cans	20.5	11.7	2.9%
<b>Non-Rigid Plastics</b>	<b>148.9</b>	<b>74.1</b>	<b>21.1%</b>	Aluminum Cans	20.9	15.4	2.9%
Plastic Bags	21.3	11.7	3.0%	Other Metal	6.2	5.2	0.9%
Other Film	103.0	62.2	14.6%				
Expanded Polystyrene	24.6	17.5	3.5%	<b>Other</b>	<b>48.4</b>	<b>45.5</b>	<b>6.8%</b>
				Human Wastes	-	Not found	0.0%
<b>Glass</b>	<b>11.4</b>	<b>9.6</b>	<b>1.6%</b>	Food	1.1	2.2	0.2%
Alcohol Bottles	8.5	7.8	1.2%	Construction Materials	10.2	12.0	1.4%
Beverage Containers	1.5	2.2	0.2%	Textiles/Shoes	10.9	10.6	1.5%
Other Ceramic or Glass	1.5	2.2	0.2%	Bulky Items	-	Not found	0.0%
				Vehicle Debris	24.7	31.4	3.5%
<b>Tobacco</b>	<b>37.4</b>	<b>25.9</b>	<b>5.3%</b>	Other Items	1.5	2.2	0.2%
Cigarette Butts, Cigar Tips, et	37.4	25.9	5.3%				
				<b>Total</b>	<b>707.3</b>		<b>100%</b>
				<b>No. of Samples</b>	<b>13.0</b>		

**Table 11. Visible Litter Less Than Four Inches, Kent County**

Material	Pieces per Mile			Group	Pieces per Mile		
	Average	Conf. Int. (90%)	Composition		Average	Conf. Int. (90%)	Composition
<b>Rigid Plastic</b>	<b>226.4</b>	<b>137.3</b>	<b>5.9%</b>	<b>Paper</b>	<b>842.1</b>	<b>938.3</b>	<b>22.0%</b>
Beverage Bottles	21.7	44.5	0.6%	OCC	-	Not found	0.0%
Alcohol Bottles	-	Not found	0.0%	Recyclable Paper	499.4	636.1	13.1%
Bottles	-	Not found	0.0%	Single-Use Food Service	138.0	180.9	3.6%
Single-Use Food Service	29.5	44.5	0.8%	Other Paper	204.7	191.6	5.4%
Other Plastic Packaging	51.2	60.3	1.3%				
Other/Non-Packaging Plastics	124.1	104.4	3.2%	<b>Metal</b>	<b>173.7</b>	<b>212.8</b>	<b>4.5%</b>
				Aluminum Alcohol Cans	-	Not found	0.0%
<b>Non-Rigid Plastics</b>	<b>612.5</b>	<b>446.9</b>	<b>16.0%</b>	Aluminum Cans	86.8	178.2	2.3%
Plastic Bags	-	Not found	0.0%	Other Metal	86.8	137.3	2.3%
Other Film	459.0	325.3	12.0%				
Expanded Polystyrene	153.5	140.8	4.0%	<b>Other</b>	<b>153.5</b>	<b>124.7</b>	<b>4.0%</b>
				Human Wastes	-	Not found	0.0%
<b>Glass</b>	<b>-</b>	<b>Not found</b>	<b>0.0%</b>	Food	-	Not found	0.0%
Alcohol Bottles	-	Not found	0.0%	Construction Materials	21.7	44.5	0.6%
Beverage Containers	-	Not found	0.0%	Textiles/Shoes	58.9	60.3	1.5%
Other Ceramic or Glass	-	Not found	0.0%	Bulky Items	-	Not found	0.0%
				Vehicle Debris	21.7	44.5	0.6%
<b>Tobacco</b>	<b>1,816.0</b>	<b>1,545.1</b>	<b>47.5%</b>	Other Items	51.2	60.3	1.3%
Cigarette Butts, Cigar Tips	1,816.0	1,545.1	47.5%				
				<b>Total</b>	<b>3,824.3</b>		<b>100%</b>
				<b>No. of Samples</b>	<b>13.0</b>		

## Sussex County

**Table 12. Visible Litter Greater Than Four Inches, Sussex County**

Material	Pieces per Mile			Group	Pieces per Mile		
	Average	Conf. Int. (90%)	Composition		Average	Conf. Int. (90%)	Composition
<b>Rigid Plastic</b>	<b>317.3</b>	<b>79.1</b>	<b>25.9%</b>	<b>Paper</b>	<b>226.0</b>	<b>61.1</b>	<b>18.5%</b>
Beverage Bottles	137.8	44.4	11.3%	OCC	27.7	21.8	2.3%
Alcohol Bottles	36.3	13.1	3.0%	Recyclable Paper	37.9	29.0	3.1%
Bottles	20.1	9.0	1.6%	Single-Use Food	79.2	26.4	6.5%
Single-Use Food Service	77.4	27.5	6.3%	Other Paper	81.2	21.2	6.6%
Other Plastic Packaging	7.7	3.3	0.6%				
Other/Non-Packaging Plastics	38.1	16.6	3.1%	<b>Metal</b>	<b>160.0</b>	<b>43.7</b>	<b>13.1%</b>
				Aluminum Alcohol	77.0	26.2	6.3%
<b>Non-Rigid Plastics</b>	<b>310.7</b>	<b>99.3</b>	<b>25.4%</b>	Aluminum Cans	71.6	17.8	5.8%
Plastic Bags	61.6	32.2	5.0%	Other Metal	11.4	7.0	0.9%
Other Film	191.6	52.0	15.6%				
Expanded Polystyrene	57.5	29.5	4.7%	<b>Other</b>	<b>123.5</b>	<b>44.2</b>	<b>10.1%</b>
				Human Wastes	-	Not found	0.0%
<b>Glass</b>	<b>43.9</b>	<b>13.9</b>	<b>3.6%</b>	Food	2.5	1.8	0.2%
Alcohol Bottles	33.4	11.7	2.7%	Construction M	36.5	21.9	3.0%
Beverage Containers	7.3	4.3	0.6%	Textiles/Shoes	15.4	10.2	1.3%
Other Ceramic or Glass	3.2	1.8	0.3%	Bulky Items	-	Not found	0.0%
				Vehicle Debris	48.0	23.8	3.9%
<b>Tobacco</b>	<b>42.9</b>	<b>12.2</b>	<b>3.5%</b>	Other Items	21.0	8.0	1.7%
Cigarette Butts, Cigar Tips, et	42.9	12.2	3.5%				
				<b>Total</b>	<b>1,224.3</b>		<b>100%</b>
				<b>No. of Samples</b>	<b>26.0</b>		

**Table 13. Visible Litter Less Than Four Inches, Sussex County**

Material	Pieces per Mile			Group	Pieces per Mile		
	Average	Conf. Int. (90%)	Composition		Average	Conf. Int. (90%)	Composition
<b>Rigid Plastic</b>	<b>245.5</b>	<b>121.6</b>	<b>6.6%</b>	<b>Paper</b>	<b>672.7</b>	<b>289.1</b>	<b>18.1%</b>
Beverage Bottles	15.3	44.5	0.4%	OCC	45.9	133.6	1.2%
Alcohol Bottles	-	Not found	0.0%	Recyclable Paper	130.1	153.8	3.5%
Bottles	-	Not found	0.0%	Single-Use Food	87.7	58.4	2.4%
Single-Use Food Service	38.3	45.6	1.0%	Other Paper	409.1	160.3	11.0%
Other Plastic Packaging	61.2	83.6	1.6%				
Other/Non-Packaging Plastics	130.8	70.1	3.5%	<b>Metal</b>	<b>166.9</b>	<b>137.4</b>	<b>4.5%</b>
				Aluminum Alcohol	23.0	66.8	0.6%
<b>Non-Rigid Plastics</b>	<b>978.0</b>	<b>307.7</b>	<b>26.3%</b>	Aluminum Cans	21.6	22.3	0.6%
Plastic Bags	45.9	112.7	1.2%	Other Metal	122.4	128.8	3.3%
Other Film	706.8	273.8	19.0%				
Expanded Polystyrene	225.4	143.4	6.0%	<b>Other</b>	<b>128.7</b>	<b>125.1</b>	<b>3.5%</b>
				Human Wastes	-	Not found	0.0%
<b>Glass</b>	<b>44.5</b>	<b>69.6</b>	<b>1.2%</b>	Food	21.6	22.3	0.6%
Alcohol Bottles	23.0	66.8	0.6%	Construction Materials	23.0	49.0	0.6%
Beverage Containers	-	Not found	0.0%	Textiles/Shoes	7.7	22.3	0.2%
Other Ceramic or Glass	21.6	22.3	0.6%	Bulky Items	-	Not found	0.0%
				Vehicle Debris	76.5	111.6	2.1%
<b>Tobacco</b>	<b>1,489.4</b>	<b>408.2</b>	<b>40.0%</b>	Other Items	-	Not found	0.0%
Cigarette Butts, Cigar Tips	1,489.4	408.2	40.0%				
				<b>Total</b>	<b>3,725.7</b>		<b>100%</b>
				<b>No. of Samples</b>	<b>26.0</b>		

## Comparison by Road Type

Table 14 compares visible litter pieces per road mile for the three road types. As illustrated by Table 14, visible litter increases as the traffic volume increases, which is not surprising. That is the reason why all of the county and the transfer station results have been “weighted” to account for the actual percent of each type of roadway in each county and leading to the two studied transfer stations.

**Table 14. Visible Litter by Road Type**

MATERIAL	STATE ROADS		US HIGHWAY		INTERSTATE	
	> 4	< 4	> 4	< 4	> 4	< 4
Paper	170	411	295	1,710	1,144	4,752
Rigid Plastics	221	164	339	478	440	880
Plastic Bags and Film	137	387	351	1,081	361	4,928
Expanded Polystyrene	26	106	62	478	88	5,456
Glass	36	12	18	38	9	-
Metal	109	23	104	402	106	
Tobacco	44	1,455	27	2,401	70	4,928
Other	56	82	230	490	1,786	4,048
<b>Total</b>	<b>798</b>	<b>2,640</b>	<b>1,427</b>	<b>7,078</b>	<b>4,004</b>	<b>24,992</b>

## Impact of Universal Recycling on Visible Litter

As stated in the introduction, one issue that has been raised is whether the advent of universal recycling, with single stream recyclables emptied into trucks which then drive to either the Route 5 or Milford Transfer Station, has led to an increase in visible litter.

One way to address this issue is to compare visible litter counts along the roads leading to the two transfer stations against the statewide average visible litter count per mile exclusive of the roads leading to the two transfer stations. Table 15 presents the results. For purposes of comparison, Table 15 includes the confidence intervals for both the statewide average litter counts, and for the average of the two transfer stations.

As illustrated by Table 15, visible pieces greater than four inches leading to the two DSWA transfer stations fall within the range of the statewide average, indicating that there is no statistical difference in litter quantities near the DSWA transfer stations when compared to the statewide average.

However, for litter pieces under four inches, there are *potentially* more pieces of rigid plastics, plastic film and glass leading to the two transfer stations when compared to the statewide data (as illustrated by the green highlights). However, because of the large confidence intervals associated with both the transfer station and statewide data, the Project Team cannot conclusively state that the actual number of small pieces are greater because the data fall within the tail of the transfer station bell curve created by the analysis. That is, it is also possible that the number of small litter pieces are statistically equal to the statewide average.

For example, the number of rigid plastic pieces under four inches found near the two transfer stations range from 453 pieces plus or minus 218.7 pieces; or somewhere between 234 and 672 pieces per mile compared to the statewide range of 197 to 387 pieces per mile.

Just as importantly, as stated earlier in the report, the data for pieces under four inches are much more subject to the impact of roadside mowing, and therefore are significantly less reliable than the data for pieces over four inches.

A general conclusion can be that it is *possible*, especially for plastic film, that recycling trucks are contributing to roadside litter of plastic film, but the impact is relatively insignificant; implying that continued inspections by DSWA of recycling trucks to assure they are properly closed during driving and delivery is important.

**Table 15. Comparison of Visible Litter, Statewide Average and on Roads Leading to Transfer Stations**

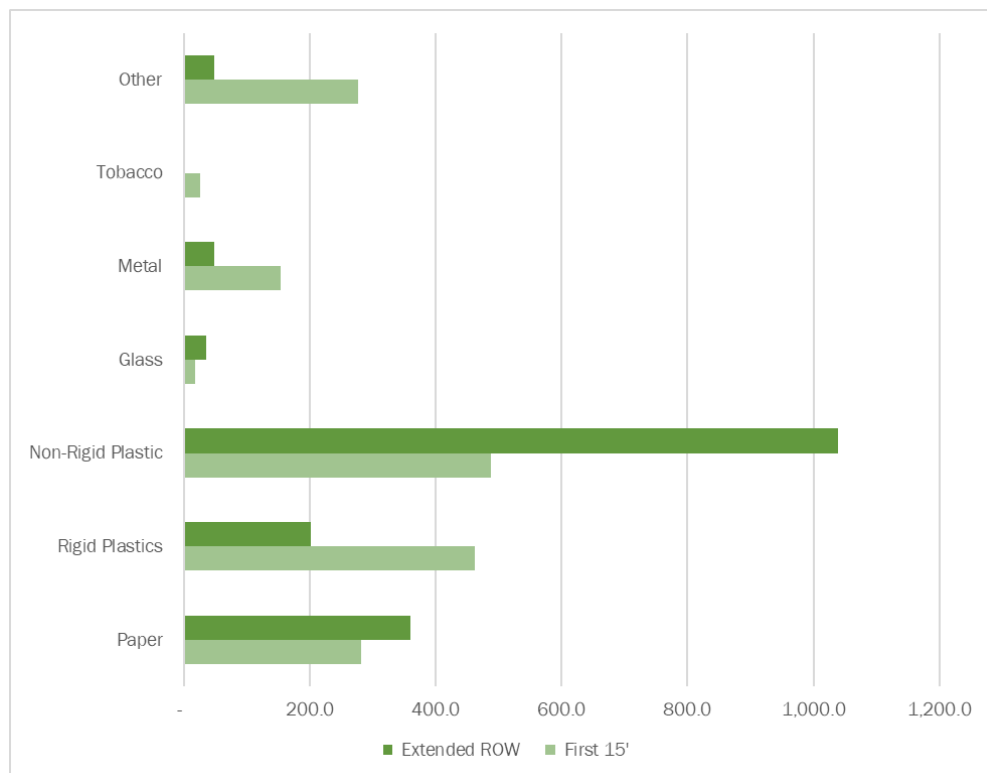
MATERIAL	STATEWIDE		CONF. INTERVAL		TRANSFER STATIONS		CONF. INTERVALS	
	> 4	< 4	> 4	< 4	> 4	< 4	> 4	< 4
Paper	247	960	63	476	205	415	61.0	245.9
Rigid Plastics	263	291	49	96	246	453	85.5	218.7
Plastic Bags and Film	208	849	55	294	256	1,038	117.7	426.9
Expanded Polystyrene	37	461	15	238	47	217	21.1	141.8
Glass	32	32	9	30	39	141	19.4	96.5
Metal	103	135	25	82	78	166	29.3	77.5
Tobacco	40	1,850	9	480	26	1,061	8.8	581.2
Other	190	390	81	197	130	285	42.3	160.5
<b>Total</b>	<b>1,120</b>	<b>4,967</b>			<b>1,027</b>	<b>3,776</b>		

## Expanded Survey Area

It became clear during surveying that the National Study standard of a 15-foot depth of the right-of-way appeared to under-estimate the amount of large, blown litter visible along the roadways. While not part of the scope, four sample locations were expanded from 15-feet to 30-feet and the same litter count for large litter (>4") made. In particular, these four extended segments were noteworthy because they had a brush line or other noticeable transition from mowed ground to overgrowth, which essentially served as a catch for windblown litter. Figure 4 illustrates the data collected. The results, while not statistically significant, clearly illustrate the impact that plastic film and expanded polystyrene (materials subject to blowing and that do not break down like paper) have on visible litter.

Because of the growing prevalence of plastics in the waste stream and their proclivity to be windblown, future roadside visible litter studies should consider modifying the methodology to investigate this observation in more detail.

**Figure 4. Comparison of Visible Litter Greater Than Four Inches, First 15 Feet and Second 15 Feet**



## Conclusions

This report establishes baseline litter data consistent with the Keep America Beautiful National Study methodology, which Delaware can use to measure changes over time in pieces by material type of visible litter along Delaware roads. From this first survey, the following conclusions can be drawn.

- On average, Delaware highways have 1,120 pieces of litter larger than four inches every centerline mile, or double that (2,240 pieces) per roadway mile.
- On average, Delaware highways have 4,967 pieces of litter less than four inches every centerline mile, or 9,934 pieces per road mile.
- The national average number of litter pieces four inches and over measured in 2009 was 608 pieces per centerline mile which is 512 more pieces than Delaware's average; however there have been such significant increases in the amount of plastic waste and litter subsequent to 2009 that it would be prudent to wait until the 2018 National Study is completed before making a comparison of Delaware roads with national averages.
- The national average number of litter pieces under four inches per centerline mile measured in 2009 was 6,729 which is significantly greater than the Delaware statewide average; however, in the case of small litter pieces, consumption of tobacco has been significantly reduced subsequent to 2009, therefore, as with large pieces, it is prudent to wait for the 2018 national study results before making a comparison.
- Plastics make up 45 percent of total litter over four inches, compared to 35 percent in the 2009 national study; and plastics and tobacco products make up just under 70 percent of litter under four inches.
- There is no statistical difference between roads leading to the two DSWA transfer stations accepting recyclables and the statewide average for litter pieces four inches and greater.
- Pieces of plastic litter smaller than four inches are slightly greater along the roadways leading to the two transfer stations accepting single stream recycling when compared against the weighted statewide average, although barely statistically significant.
- Observations made during sampling, and measured at four sample locations, indicate that the existence of a line of transition from mowed ground to un-mowed ground, brush, or any other overgrowth creates a catch for windblown litter and that large litter items may increase in this zone. Future studies should consider expanding the width of the sample segment from 15-feet to 30-feet to better capture the prevalence of blowing visible litter comprised primarily of plastic film, expanded polystyrene and paper.